

RESTORING FEN GRASSLAND

A STUDY OF MOWING IN SOUTHERN SWEDEN

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ABSTRACT

The few remaining calcareous fen grasslands of S Sweden are of considerable conservation value. A major problem is that cessation of grazing in most unfertilized pasture has usually led to rapid succession towards species-poor tall-herb communities. A five-year mowing experiment was set up in a field that had been abandoned for 15 years. The dominants in the original fen grassland were Filipendula ulmaria, Urtica dioica and Carex disticha. Filipendula and Urtica gradually decreased in cover while Poa trivialis increased. There was a general reduction in height, and a slight increase in number of species; but the resulting vegetation still showed little resemblance to fen grassland, though a few typical species, e.g. Selinum carvifolia, reappeared. The need for appropriate management of good fen grasslands is thus evident.

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INTRODUCTION

Fen grassland is one of many plant communities that have arisen through the activity of Man down the ages. With the cessation of mowing and grazing, rapid changes usually take place; such succession has been studied in grassland in S Sweden by Persson (1984) and Regnéll (1980). The changes are often irreversible, at least during observable time. The general statement made by Westhoff (1970, p. 108) on management sums this up: "Continuity is of utmost importance ...". My study demonstrates this.

Fens and fen grassland in S Sweden and their management have been studied by Tyler (1981, 1984) and Regnéll (1982) in a project sponsored by the Swedish National Environmental Protection Board. Similar work on fens in Norrland (the far north of Sweden) has been done by Elveland (1975, 1978) who has also studied the effects of various management methods in these fens and other wetlands in the north (Elveland, 1979, 1983, 1984a, 1984b, 1984c, 1985; Elveland & Sjöberg 1982).

STUDY AREA

The investigation was carried out in southernmost Sweden, near Örup castle, about 10 km NE of Ystad (Fig. 1). There, in the valley of Örupsån (the river Örup), are extensive unfertilized pastures comprising Schoenus fen (Tyler, 1975) and fen grassland (Regnéll, 1980). During the 18th and 19th centuries, the present-day pastures were mown for hay, the cattle grazing the surrounding higher land where deciduous forest has since developed.

The till in the valley is clayey, rich in lime, but with Archaean boulders. The peat layer in the fens is thin.

In part of the fen grassland area grazing was discontinued 15 years before the investigation was initiated in 1976. By then succession had given rise to tall-herb vegetation dominated by Filipendula ulmaria, Carex disticha and Urtica dioica with an average of only 5.5 species/0.1 m². The experiment was set up less than 20 m from the drystone wall separating the abandoned field from the field that is still being grazed. The low, tussocky vegetation in the grazed field is species-rich (more than 15 species/0.1 m²); it is dominated by Carex panicea, C. nigra, Molinia coerulea, Serratula tinctoria, Festuca ovina, Potentilla erecta, Filipendula ulmaria and Carex disticha. The dominating bryophytes (mosses) are Campylium stellatum and Thuidium tamariscinum.

MATERIAL AND METHODS

Experimental design and field work

The aim was to see what effect removal of biomass would have on the tall-herb vegetation. What changes would occur? Would there be a trend towards the original species-rich vegetation that had existed 15 years before? The original intention was for one

plot to be mown and a second to be mown and then grazed, but it proved impossible to get permission to remove one of the animals from the grazed field for this purpose.

The experiment was initiated in the summer of 1976 (year 1) and was terminated in 1980 (year 5). Three 3x3 m permanent plots (A, B and C) were marked out 1 m apart in an area where the tall-herb vegetation was judged to be homogeneous (Fig. 2). Each year ten 0.1 m² quadrats were randomly distributed within each plot.

The quadrats were analysed with respect to percentage cover as regards vascular plants, bryophytes and litter. Depth of litter layer and height of vegetation were also recorded; species in a plot that did not fall within a quadrat were noted. In year 5 the occurrence of buds and flowers on Filipendula ulmaria, Cirsium palustre and Urtica dioica in the quadrats was recorded.

Plots A and B were then mown (using a scythe) and raked, C being left as control. The plots were mown at midsummer in year 1 and in mid-July in the following years. In year 4, they were mown as usual but the analyses had to be omitted.

For vascular plants the nomenclature follows Lid (1974), for bryophytes Nyholm (1956--69). Juncus effusus is included in J. conglomeratus. In Tables 1 and 2 the scientific names are abbreviated according to Österdahl et al. (1977) -- Table 3 gives the names in full.

Numerical methods

The results of the vegetation analyses for the 10 quadrats in each of the 3 plots for 4 years (120 quadrats in all) were stored in the RUBIN system (Rühling, 1981). Information on species composition in each plot for each year was summarized by calculating frequency (F) and characteristic degree of cover (C) for the 10 quadrats within the plot, C being calculated as the mean of the cover percentages in the quadrats in which a species occurs (cf. Malmer, 1962, p. 49). Reference is made by using the letter designating the plot, together with the year, e.g. B5 denotes the analyses from plot B made in year 5 (as in Table 1).

For ordination purposes mean cover percentages of the 10 quadrats in each of the 3 plots were calculated for each of the 4 years, resulting in 12 sets of data; a species that occurred in a given plot though not falling within any of the quadrats was given a mean cover value of 0.1%, this being the lowest possible value for a species occurring in a single quadrat. The analyses of the 20 quadrats in each of the two 100 m² plots denoted A and C in Regnéll (1980) and here designated plots I and II were used for comparison. Ordination by unstandardized principal components analysis (PCA) was used (ORDINA, Roskam, 1971) on the 12 data sets (Fig. 3). A second ordination using 10 data sets, 8 from the mown plots A and B, and 2 from plots I and II yielded the results shown in Fig. 6.

The classification program TABORD (van der Maarel et al., 1978; Persson, 1977) was also used, mainly to produce the summary of

species composition presented in Table 1.

For each species, presence/absence was calculated for each of the 12 data sets and compared with the total of the remaining 11 sets for the species. Significant differences are given in Table 2. When the same calculations were made on the 4 data sets for the control plot no significant differences were obtained.

The TABORD Chi-square calculation routine, based on the Chi-square distribution, which is continuous, was used, whereas the sampling results were discontinuous. To remove falsely significant differences, I applied Yates's correction for continuity according to Ferguson (1959, p. 171) when any of the frequencies was less than 5. Table 2 is based on about 400 tests; a few of the significant values may therefore be the result of random effects.

RESULTS

In the control plot the changes were negligible throughout all five years (Fig. 3). The total number of species remained fairly constant and the mean number of species in the quadrats remained low. No appreciable change in species composition was found. Chi-square tests based on presence/absence indicate no significant changes for any of the species. The fluctuations in mean cover noted for many species can be explained by natural variation from year to year, random error and errors in measurement. A layer of litter, almost 5 cm deep, covered more than 80% of the ground. Fig. 4 gives the impression that the vegetation was considerably lower in year 1 than in subsequent years; however, this is because measurements were made about two weeks earlier that year. To sum up, the vegetation in the control plot can be characterized as semi-stable, i.e. it is stable as long as no woody species manage to invade.

What was the effect of mowing? The vegetation in plots A and B diminished gradually in height until it was 2--3 dm lower than that in the control plot (Fig. 4). The amount of litter was greatly reduced: by year 5 the percentage cover was low and the layer was no more than 1--2 cm deep. The mean number of species in the quadrats rose significantly ($p < 0.05$) in both mown plots but not in the control plot (t-test).

The significant differences in presence/absence for each plot each year compared with the rest of the material reveal changes for some species (Table 2). With time, the number of significant changes in the mown plots increased. Urtica dioica and Galium aparine decreased significantly in plots A and B; Phalaris arundinacea did so in A5 only. For the remaining species shown in Table 2, for example Ranunculus repens and Galium palustre tended to increase in the mown plots. There was also a tendency for new species to appear sporadically (not statistically relevant) in plots A and B during years 3--5, e.g. Selinum carvifolia and Ranunculus auricomus (Table 1). The presence of these two species, which also occur in the grazed field (Table 3), is an indication of rich conditions.

For some species in the mown plots frequency remained virtually



unchanged though other effects of mowing could sometimes be observed. For instance, there was a marked decline in mean cover for Filipendula ulmaria and a rise for Poa trivialis (Fig. 5), though both species occurred in such abundance that they were almost constant, i.e. frequency was almost 100%. For most species, however, the same general trend was found for mean cover as for frequency, e.g. for Urtica dioica (Fig. 5, Table 2).

The response of some species to mowing was more complicated (Table 1). For Cirsium palustre there was an initial rise in frequency and cover, but in year 5 a considerable decline in cover was observed. In the control plot, both remained low. For Phalaris arundinacea there was also an initial increase in cover followed by a decrease (in plot A only one culm appeared in year 5). Galium uliginosum appeared in year 2, but had disappeared the following year. One of the dominants, Carex disticha, remained fairly constant in cover (Fig. 5).

For the bryophyte Brachythecium rutabulum frequency in year 2 was significantly higher in the mown plots, probably because rainfall and humidity were higher during the period March to June, i.e. immediately preceding the analysis (Månadsöversikt ..., 1976--1980). Since a similar though not significant peak was observed in the control plot that year no conclusions should be drawn on the response of bryophytes to mowing.

Flowering is also affected by mowing. For example, from year 2 Filipendula ulmaria flowered less prolifically in the mown plots. In year 5 Filipendula and Urtica dioica flowered abundantly in all quadrats of the control plot. In the mown plots, however, flowers (or buds) of Filipendula occurred only in 13 out of 17 quadrats and of Urtica in 1 of 6; there were also fewer flowers on each stem. Cirsium palustre, on the other hand, flowered only in the mown plots.

Though ordination results (Fig. 3) confirmed that mowing induced considerable changes in the vegetation Fig. 6 shows there was no clear trend towards the status of the adjacent grazed field.

CONCLUSIONS & DISCUSSION

The results show that in some years mowing affects tall-herb meadows of this kind in several ways. For instance, the vegetation diminishes in height and the number of species increases.

In the control plot the vegetation was semi-stable throughout the experiment. Niering & Goodwin (1974) report similar breaks in the development of succession in North American "relatively stable shrub communities" that withstood invasion by trees for many years. From the west coast of Sweden, Olsson (1984, p. 22) describes herb-dominated old fields, that have resisted invasion of trees from seed for more than three decades. Vinther (1983, p. 89), who studied the invasion of a Danish meadow by Alnus glutinosa, also concludes that in ungrazed meadows (or in heavily grazed meadows) the chance of establishment from diaspores is minimal.

Annuals such as Galium perenne soon disappear with mowing. Perennial herbs (e.g. Filipendula ulmaria and Urtica dioica) that have much of their biomass cut off suffer a substantial reduction in cover and flowering. Some of the graminoids are less sensitive: the tall sedge Carex disticha, which has vigorous rhizomes, while becoming shorter here suffered no reduction in frequency or cover. However, the initial increase in cover found for Phalaris arundinacea was later replaced by a decrease despite the fact that it is rhizomatous. In the long run Phalaris disappears completely with mowing (cf. Elveland, 1985, p. 198).

When the cut herbage is removed together with the litter competition for light is greatly reduced, which for certain species is a most important factor contributing to increase in cover. This was especially noticeable for the perennial grass Poa trivialis, an original component of the tall-herb vegetation that readily increases by means of leafy, creeping stolons. Ranunculus repens, that is also stoloniferous and roots at the nodes, invaded the mown plots in year 3, and by the end of two years had increased considerably in cover. The scrambling annual Galium aparine was replaced by the creeping perennial G. palustre that is not cut by the scythe.

The increase in cover of the biennial Cirsium palustre, followed by a decrease, could be interpreted as a random effect. However, this response was not altogether surprising. Since in tall-herb meadow vegetation the first-year basal rosettes suffer from lack of light, in this case mainly because of shading by Filipendula ulmaria, the rootstocks are small, few Cirsium plants survive and flowering is poor. After the plots had been mown light conditions at ground level improved for the first-year Cirsium seedlings, and some of the second-year plants that had had their stems cut off before setting seed probably also survived till their third year. However, as competition for light increased near ground level, for instance from Poa trivialis, it became increasingly difficult for seedlings to establish.

On the other side of the drystone wall, grazing and trampling by cattle has prevented Filipendula ulmaria, Carex disticha, Galium aparine and Urtica dioica from expanding as they had done in the abandoned field during the 15 years preceding the study. The fen grassland vegetation still existing in the grazed field is species-rich, as seen in Table 3. The results of the study do not suggest that mowing can counteract the changes due to 15 years without grazing (Fig. 6) -- reversion to fen grassland vegetation lies in the far distant future, though there is an abundant source of propagules of fen grassland species in the study area. One reason is that creeping species such as Ranunculus repens and Poa trivialis are favoured by mowing, and therefore probably constitute a hinder to recruitment from seed. The likelihood of seeds reaching the ground and of seedlings establishing will presumably be greatest after the first few years of mowing and removal of litter and cut herbage. van der Maarel (1980) also found limited effects of mowing in an orchard, where the main effect was the disappearance of Urtica dioica (in non-fertilized plots) whereas species number remained rather low.

From the point of view of the nature conservationist, the results of abandoning the fen grassland field for fifteen years have been negative, since it entailed a heavy loss of species and a simplification of structure. Compare this development with the situation in Uppland (the province directly north of Stockholm) where succession in pastures has been studied since abandonment in 1955 (Fogelfors & Steen, 1982). The changes there were also negative, though less rapid and in some kinds of pasture presumably not irreversible. Moreover, even after 13 years (1968) the number of herbs was still fairly high, even in plots that had been fertilized. It was not until 1980 that the treatment resulted in a uniform and uninteresting flora (for example, on clayey soils only Elytrigia repens, Anemone nemorosa, Anthriscus sylvestris, Cirsium arvense, Filipendula ulmaria and Rosa majalis remained). In the unfertilized plots there was a considerable loss of species, but even so roughly half the number of species persisted. At Örup the changes were far more drastic after only 15 years. Fogelfors and Steen also studied mowing as an alternative to grazing, and in the main obtained positive results, i.e. the number of species increased. However, their results cannot be directly applied to the study of restoration, since their experiments were not set up in abandoned fields.

To sum up, my results give cause for a pessimistic view on the restoration of fen grassland by mowing when succession has resulted in a profound change in the composition of the flora; the appropriate management of remaining good fen grasslands is thus imperative. If a site is to be restored more drastic measures are needed. For instance, the removal of the topsoil to initiate a near-primary succession could give good results if this is followed by grazing or mowing. Thus fen grassland vegetation has developed in abandoned calcareous sand- or gravel-pits in many places in Sweden (Regnéll, 1982, p. 53--56) -- such sites are poor in nutrients and competition is thus weak so that seedlings of a variety of calcicole species can readily establish during a long period of years.

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Fig. 1. The study area is situated 3 km SSW of Tomelilla in SE Skåne, the southernmost province of Sweden.

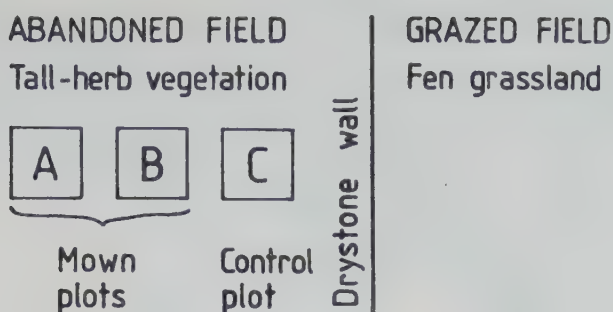


Fig. 2. Experimental design. Three 3x3 m permanent plots were marked out in tall-herb vegetation, in a field that had been abandoned 15 years previously. On the other side of a drystone wall is a field still used for grazing cattle; the fen grassland vegetation there is described in Regnéll (1980) -- cf. Table 3.

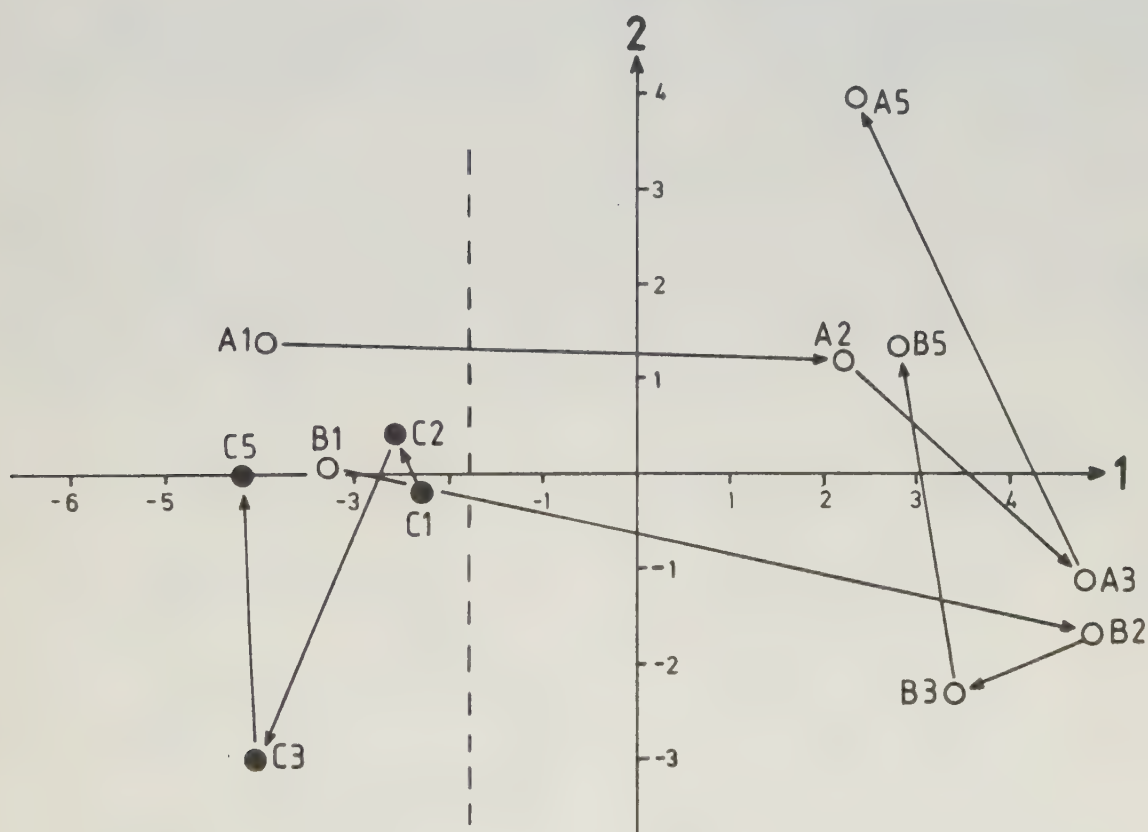


Fig. 3. Ordination by PCA to compare changes in the mown plots (A) and (B) with changes in the control plot (C). A1 and B1 denote the mown plots before mowing in year 1 -- hence the close resemblance to C. The effects of mowing are evident, especially after year 1. (Arrows indicate the direction of change from year to year.)
 --The extracted variance shown in the figure amounts to 67% (53% along axis 1 and 14% along axis 2).

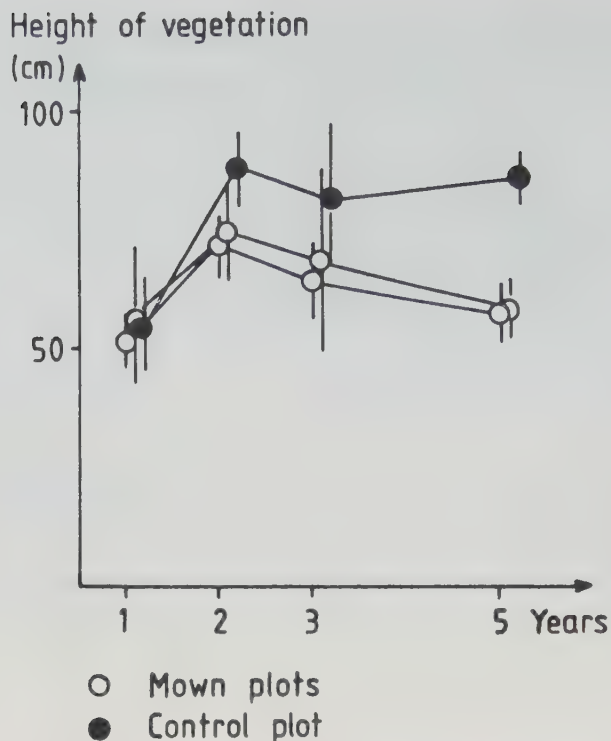


Fig. 4. The vegetation in the mown plots gradually became shorter than that in the control plot. In year 1 the plots were mown a fortnight earlier than in subsequent years, hence the low values for year 1.

-- Vertical lines denote standard deviation, $SDNn-1U$.

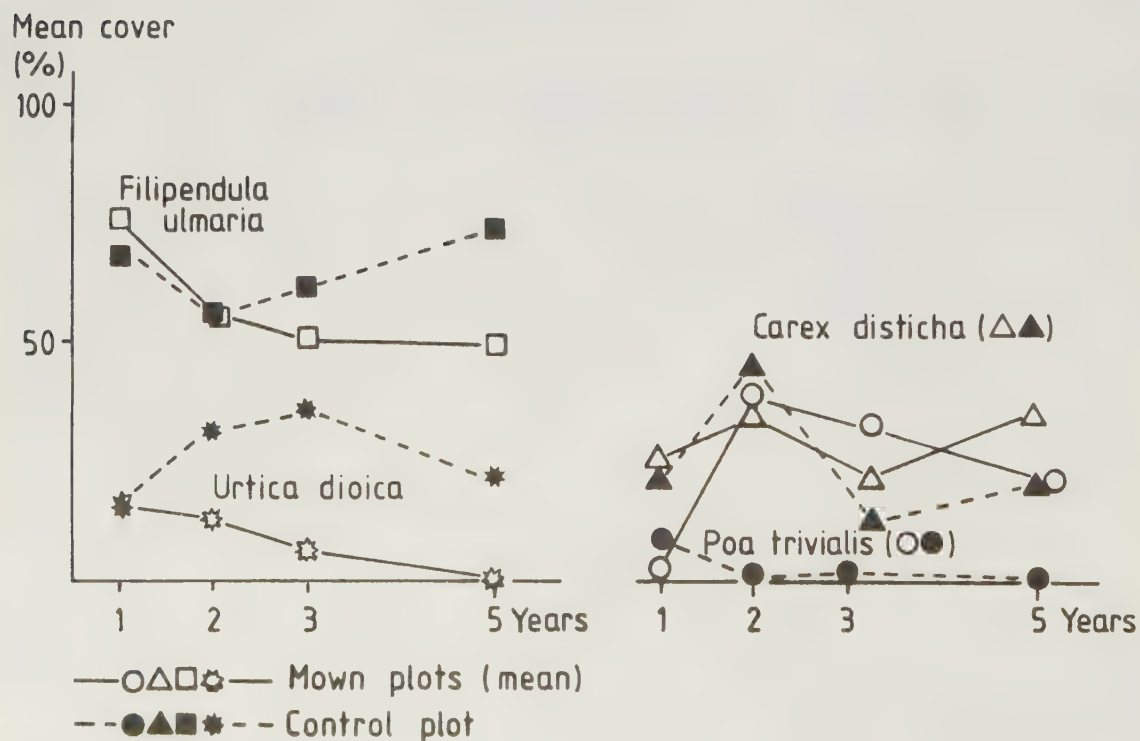


Fig. 5. Changes in mean cover for four common species in the two mown plots taken together compared with changes in the control plot. This shows the different effects of mowing on some species.

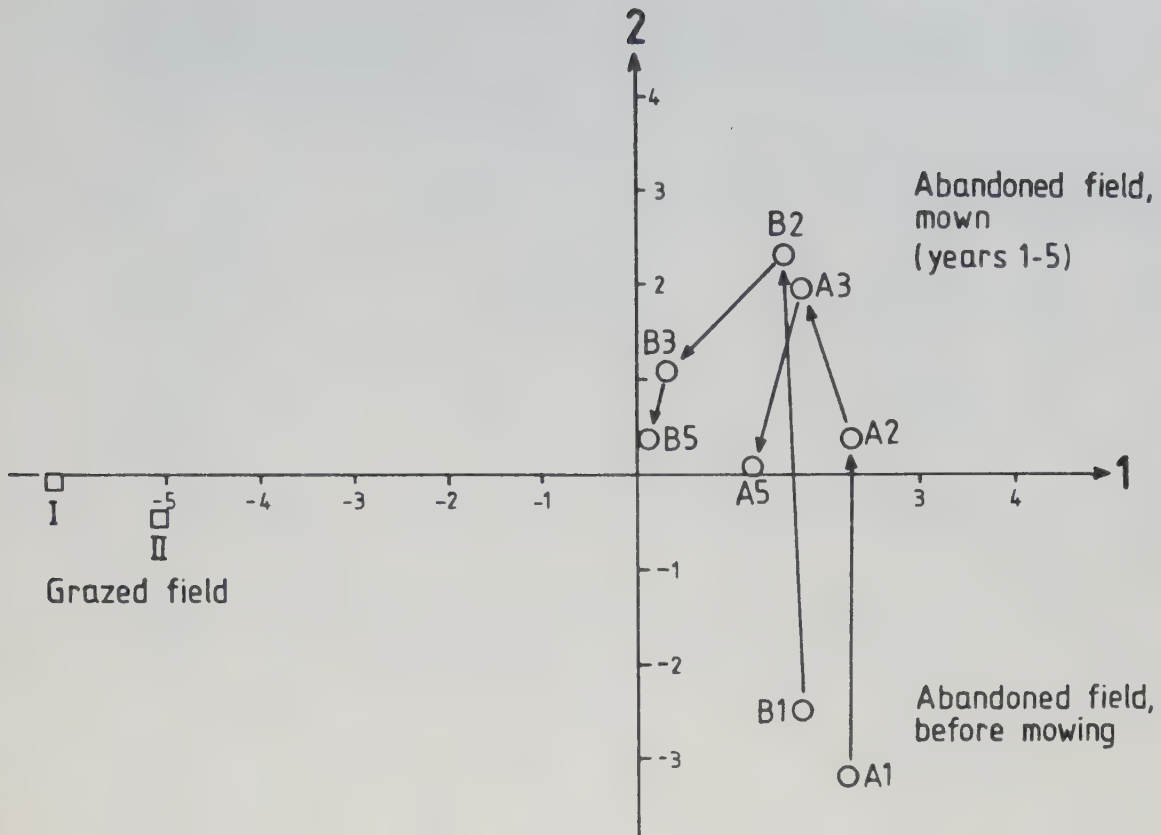


Fig. 6. Ordination by PCA to show changes in vegetation in the mown plots A and B and the status of plots I and II in the grazed field. The diagram illustrates the changes induced by mowing, as well as the persisting difference between the plots in the grazed field and the mown plots in the abandoned field. -- The extracted variance shown in the figure amounts to 80% (60% along axis 1 and 20% along axis 2).

Table 1. A summary of species composition in plots A, B and C in years 1, 2, 3 and 5. F= frequency C= characteristic degree of cover. * denotes species in a plot that did not fall within a quadrat.

	C O N T R O L						Y E A R 1			Y E A R 2			Y E A R 3			Y E A R 5		
	C1	C2	C3	C5	F	C	A1	B1	A2	B2	A3	B3	A5	B5	F	C	F	C
GALI APA	90	2	80	14	100	2	80	1	70	1	30	1	30	1	10	1		
URTI DIO	100	16	100	35	100	21	80	14	100	20	90	7	90	21	90	6	30	1
FILI ULM	90	78	100	56	90	68	90	89	90	79	90	71	70	67	90	61	80	60
PHAL ARU	70	7	50	8	80	5	40	5	40	8	40	17	70	16	90	11	90	14
CIRS PAL	30	7	10	5	30	1	30	1	80	9	70	9	90	30	90	2	40	1
C DISTIC	100	21	100	45	100	13	100	24	100	25	100	37	100	32	100	28	100	38
POA TRI	90	10	80	1	50	4	70	1	90	33	100	46	100	38	100	23	70	25
RANU ACR	10	1	10	1														
C NIGRA								*										
GALEOPSZ							10	1	10	1								
FEST RUB																		
CALT PAL	10	1	10	1			10	1			10	1			20	10		
CIRS OLE			*														10	1
EPIL PAR																	10	30
GALI ULI																*		10
SELI CAR								*										
JUNC CON																		
CIRS VUL			10	20	*				*									
LATH PRA							*											
GALI PAL																		
MYOS PAL																		
RANU AUR	*																	
RANU RNS																		
MENT ARV																		
RANU FLA																		
TARA/VUL																		
TRIF REP																		
GLYC FLU																		
BRYOPHYTES																		
BRAC RUT	10	1	40	8	20	2	60	19	20	5	90	2	80	13	40	2	40	1
MNIU CUS																		
MNIU UND																		
CALL CUS																		
SPEC. No	11	12	9	12	11	12	11	12	11	17	13	18	19	18				

Table 2. Species showing a significantly deviating presence/absence value in any of the 12 data sets from the 3 plots during the study. -- Where presence values for a set are significantly higher than the total mean of the remaining 11 sets this is denoted (+), while (-) denotes presence values that are significantly lower. Numerals denote level of significance, (1)= $p<0.05$; (2)= $p<0.025$; (3)= $p<0.01$. (Ctot+A1+B1) denotes all six unmown plots taken together, i.e. C1-C5, A1 and B1. (N.B. Plots A and B were not mown until after the analysis was made in year 1.)

	C1	C2	C3	C5	A1	B1	Ctot+ A1+B1	A2	B2	A3	B3	A5	B5	Number of observations
URTI DIO							+3					-3	-3	97
POA TRI			-2		-2		-1							95
PHAL ARU											+2	-3		74
GALI APA	+2			+3			+3				-3	-3	-3	61
BRAC RUT	-1							+3	+2					52
CIRS PAL		-1	-3		-1		-3	+2		+3		+3		52
RANU RNS							-3			+3		+3	+2	27
GALI PAL							-2				+3		+3	11
JUNC CON													+3	9
RANU FLA												+3		5
GALI ULI									+3					3
MENT ARV												+3		3

Table 3. The vegetation in the grazed field (cf. Fig. 2) is species-rich. F = frequency, C = characteristic degree of cover. (After Regnéll, 1980)

Plot	I.		II.			F		F	
	F	C	F	C		F	C	F	C
Salix repens	25	25	15	8	C. flacca	30	5	45	4
					C. hirta	-		25	2
Caltha palustris	10	8	25	10	C. hostiana	55	11	15	3
Centaurea jacea	50	7	10	12	C. nigra	65	10	75	6
Cirsium palustre	10	2	30	3	C. panicea	95	14	85	19
Equisetum arvense	5	1	55	3	C. pulicaris	30	1	20	1
Filipendula ulmaria	10	6	75	47	Deschampsia caespitosa	10	4	15	2
F. vulgaris	15	3	25	1	Eriophorum angustifolium	40	1	-	
G. boreale	35	2	60	5	Festuca ovina	40	32	30	19
G. palustre	-		20	4	F. rubra	35	4	35	2
G. uliginosum	10	2	45	2	Molinia caerulea	80	22	65	11
Geum rivale	20	8	50	15	Sieglingia decumbens	35	5	30	3
Lathyrus pratensis	35	2	30	2					
Mentha arvensis	10	1	10	1	Aulacomnium palustre	30	19	10	20
Potentilla erecta	50	12	60	4	Brachythecium curtum	-		20	4
Prunella vulgaris	25	2	-		Calliergonella cuspidata	50	9	45	5
Ranunculus acris	55	1	5	1	Campylium stellatum	50	11	15	2
Scorzonera humilis	10	2	25	3	Climacium dendroides	10	1	20	4
Selinum carvifolia	-		75	7	Ctenidium molluscum	15	19	5	3
Serratula tinctoria	50	6	50	61	Dicranum scoparium	25	15	20	31
Succisa pratensis	25	7	40	8	Drepanocladus revolvens	15	7	5	1
Valeriana dioica	30	2	15	10	Fissidens adianthoides	20	1	25	1
Vicia cracca	25	1	15	1	Mnium affine	10	1	20	1
					Thuidium tamariscinum	25	15	50	16
Anthoxanthum odoratum	10	1	15	3					
Briza media	45	2	10	2	Mean no. of spp/quadrat	15.5		17.0	
Carex disticha	45	9	90	4	Total no. of spp/plot	70		66	

Additional species present in less than 4 quadrats. Numerals represent F and C; cover value has been omitted when less than 1%:

Plot I: Quercus robur 5-5, Agrostis stolonifera 15, Arrhenatherum pratense 5, Carex sp 5, Festuca arundinacea 10, Luzula campestris 5, Achillea ptarmica 5, Anemone nemorosa 10-2, Dactylorhiza sp 5, Equisetum palustre 5, Hieracium auricula 5-15, Leontodon hispidus 15-5, Linum catharticum 5, Lotus corniculatus 5-2, Ononis hircina 5, Plantago lanceolata 10-2, Ranunculus flammula 5, Trifolium pratense 5, Bryum pseudotriquetrum et bimum 5, Campylium elodes 10, Drepanocladus vernicosus et exannulatus 10-13, Hypnum cupressiforme 5-3, Leontodon glaucum 5, Scleropodium purum 10, Thuidium recognitum 5-15, Cladonia furcata 5.

Plot II: Crataegus sp 5-60, Salix aurita 10-20, Arrhenatherum pubescens 5, Carex sp 30-2, Anemone nemorosa 5-2, Galium verum 5, Luzula multiflora 15, Lysimachia vulgaris 10-3, Ranunculus auricomus 10-2, R. flammula 10, Rumex acetosa 15-3, Trifolium pratense 5, Viola canina 10-2, Brachythecium populeum 5-2, Bryum pseudotriquetrum et bimum 5, B. sp 5, Campylium elodes 5, Mnium undulatum 5, Rhytidiadelphus loreus 5-2, Lophocolea heterophylla 10.

